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HIGH ENERGY LASER TECHNOLOGY ASSESSMENT:

VOLUME 2. PROJECT MANAGER'S REPORT - HISTORY AND LESSONS LEARNED

HARRY DIAMOND LABORATORIES

PREPARED FOR

NATIONAL SCIENCE FOUNDATION

JANUARY 1975

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AD-A010101

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High Energy Laser Technology Assessment

VOLUME 2
Project Manager's Report History and Lessons Learned

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High Energy Laser Technology Assessment—Volume 2-Edward A Brown & Joel D Goldhar

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A010101	3. RECIPIENT'S CATALOG NUMBER AD-A ØIØ 1Ø1
4. TITLE (and Subtitle) HIGH-ENERGY LASER TECHNOLOGY ASSESSMENT; Volume II: Project Manager's Report–History and Lessons Learned		5. TYPE OF REPORT & PERIOD COVERED Final, Sep 73 - Jan 75
		6. PERFORMING ORG. REPORT NUMBER N/A
7. AUTHOR(s) Edward A. Brown, Harry Diamond Laboratories with Joel D. Goldhar, National Science Foundation		8. CONTRACT OR GRANT NUMBER(s) N/A
9. PERFORMING ORGANIZATION NAME AND ADDRESS Harry Diamond Laboratories 2800 Powder Mill Road Adelphi, MD 20783 ATTN: AMXDO PP		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS N/A
11. CONTROLLING OFFICE NAME AND ADDRESS Headquarters, Department of the Army ATTN: DAMA-ARZ-B Washington, D.C. 20310		12. REPORT DATE January 1975
		13. NUMBER OF PAGES 51
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) N/A		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Distribution Unlimited

18. SUPPLEMENTARY NOTES

N/A

PRICES SUBJECT TO CHANGE

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Technology Assessment
Impact Analysis
R&D Management

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A technology assessment has been performed on the topic of high-energy lasers to acquaint the Army Staff with this relatively new concept in R&D Management. Volume II of this three-volume report contains a report by the project manager of how the study was carried out, the problems encountered, and the lessons learned which are relevant to the performance of future technology assessments by the Army.

HIGH ENERGY LASER
TECHNOLOGY ASSESSMENT

VOLUME II: PROJECT MANAGER'S REPORT—HISTORY AND LESSONS LEARNED

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with

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January 1975

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1. INTRODUCTION

Volume II of the High-Energy Laser Technology Assessment (HELTA) will address itself to the questions "how" and "why" the TA was carried out, rather than to the actual impacts of high-energy lasers. The intent is to provide reference material for a future member of the Army staff to use when called upon to perform a TA. The HELTA was an experimental effort to learn how to do a TA, probably the first such study in the Department of Defense.

The need for the Army to become acquainted with the principles of TA was perceived about two years ago, when Congress passed the Technology Assessment Act of 1972 and created the Office of Technology Assessment. Having neither experience nor expertise in the field, the decision was made to gain both by simply doing a TA, looking at it critically, evaluating mistakes and successes, and then setting down a record by which future technology assessment project managers might be guided. This volume is that record. Keeping the needs of future project officers in mind, it seems that the most effective way of communicating the lessons learned is to write in the first person, relating those experiences in an informal manner rather than the more conventional third person passive. I will try to relate them to what might be done similarly or differently in a future TA. Key points to be considered are highlighted in bold type.

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2. RATIONALE AND ORGANIZATIONAL HISTORY OF HELTA

The origin of the HELTA was the establishment of the Office of Technology Assessment (OTA) by Congress, signed into law by the President on October 13, 1972.[1] This new arm of the Congress has been empowered to perform, or cause to be performed, TA's on any subject of interest to a committee or a congressman who may have need of such information to make an informed decision. The concept of Technology Assessment is only about five years old. At the time of the establishment of the OTA, a few TA's had already been carried out on a variety of subjects by a number of different agencies, mostly federal. However, up to this time, no Department of Defense agency had involved itself in the TA process.

Mr. Harold F. Davidson of DCSRDA,* recognizing that OTA might impact upon future Army-Congress relationships and noting the potential benefits that TA might yield to the Army R&D management system, convened a symposium on 26 Oct. 1972 at Fort McNair in Washington, D. C. to discuss the principles and procedures of TA with the Army's R&D leadership. Presentations were made by leaders in the field of technology assessment. The following January, a three-day *ad hoc* working group was called together by the U. S. Army Advanced Materiel Concepts Agency to develop a suitable approach to TA for the U. S. Army Materiel Command (AMC). The meeting was chaired by Dr. Joel D. Goldhar of the National Science Foundation. Aside from the final report of this meeting,[2] little else concerning TA has since happened within AMC. However, Dr. Goldhar had been working with Mr. Davidson at the time, to formulate some actions regarding TA at the Army Headquarters level. It was decided to perform a pilot technology assessment on a topic pertinent to DOD research. This pilot TA would be performed entirely within the Army community, at the lowest possible expenditure of manpower and funds. The purposes of this study, somewhat in opposition to each other, were to learn as much as possible about TA from the standpoint of application within the Army, and to see what results the Army could expect with a minimum investment. The long-term goals were to (1) become familiar with the field, (2) acquire the data necessary to decide how the Army should respond to a future request from the OTA, and (3) judge whether it would be worthwhile to incorporate TA into the Army's formal R&D planning mechanisms.

The topic chosen by Mr. Davidson (DCSRDA) with the concurrence of the Director of Army Research, MG Charles D. Daniel, Jr., was High-Energy Lasers (HEL). The reasons for this choice were never made known to me directly although I can hazard a guess as to what they were. The field of High-Energy Lasers was young (only about seven years old); it was growing quite rapidly; the field was concentrated within a reasonably small community, the members of which were well known to each other; the technology had been

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[1] Public Law 92-484, *Technology Assessment Act of 1972*.

*Office of Deputy Chief of Staff for Research Development, and Acquisition; formerly the Office of the Chief of Research and Development (OCRD).

[2] *AMC Technology Assessment*, Report AMCA 73-004, June 1973.

receiving a certain amount of scrutiny by the Congress; and finally, the devices had never been thought of in terms of impact outside the military. All these characteristics made high-energy lasers a good candidate for a pilot TA.

The reasons for my selection as project manager were more straightforward. I had both a technical background in lasers, albeit low-energy lasers, and at least a nodding acquaintance with TA through my attendance at the Fort McNair and AMCA meetings. Thus, I was approached by Joel Goldhar at the AMCA meeting to conduct the pilot TA for Army Headquarters. I accepted the offer on the provision that the request be made and approved formally through channels. On 10 Sep. 1973, a letter signed by General Daniel was sent through AMC Headquarters to the Technical Director of the Harry Diamond Laboratories (HDL) requesting my services as Project Manager for the High-Energy Laser Technology Assessment. A favorable reply was sent back to General Daniel (again through AMC) and on 2 Oct. 1973, I was designated PM-HELTA. The Project Manager's Charter (appendix A) was signed on 14 Jan. 1974. The arrangement was that my time would be donated to The Department of the Army (DA) by HDL for the course of the study on a part-time basis. In addition, HDL would provide all the necessary facilities and support required (clerical, graphic arts, reproduction, etc.). My travel expenses were to be funded by DA as well as some limited funds for a part-time consultant on the TA methodology. As it turned out, this support was not forthcoming from DA. HDL paid for my travel and AMC paid for the consultant.

I was to be allowed total freedom to run the project. The bounds of the subject matter were to be as broad or narrow as I deemed appropriate, and the approach and methodology were at my discretion. The only condition was that this was to be more than just a TA; it was to be a learning experience for the Army. In that sense, this volume is really the final report of the HELTA project and Volumes I and III are only annexes.

The remainder of the organizational phase of the HELTA was concerned with sketching preliminary plans with Joel Goldhar and Harold Davidson. My level of security clearance was increased to what I believed would be required. A list of contact points within the technology was begun with the help of Dr. Robert B. Watson, Chief of the Physical and Engineering Science Office at OCRD. A letter of introduction for me to be sent to various members of the HEL community from General Daniel was drafted (see appendix B). It was assumed I would need something to open the door to this fairly tight-knit family of high-energy laser researchers. This turned out to be a good assumption, which brings me to my first point: **High level backing of a TA, which is usually a controversial undertaking anyway, is necessary** to get the project off the ground.

Perceiving that this was hardly going to be a one-man job, I enlisted the support of Dr. John L. Scales, III, a physicist employed at HDL, to help with the technical aspects of the study. HDL permitted allocation of one-quarter of his time to the project, although it turned out that only one-tenth of his time was required.

To conclude this chapter, there are some points that should be made concerning the selection of a PM for a future TA. The Fort McNair and AMCA meetings, while not turning me into a TA evangelist, did convince me of the need for something like TA. Whether TA

was THE answer or not, I didn't know, but I was willing to look into it with an open mind. There was liable to be a certain amount of personal risk involved in delving into such a new area as TA. The work would take me out of the laboratory situation for a year or more and, considering the avant-garde nature by which futuristic type studies are held by some members of the scientific community, my professional credibility could possibly be hurt. From this experience I can state that when considering the selection of a PM for future TA, **the Project Manager must have a personal commitment to the goals of TA in general and specifically to the study itself.** Otherwise, the criticism he will meet along the way will cause him to compromise the objectives of the study.

Before continuing, it should be noted that a good deal of confusion concerning TA has been caused by the unfortunate choice of nomenclature particularly with respect to the Department of Defense. Used in the DOD context, "technology assessment" has usually meant literally the assessment of the level or state-of-the-art of some particular technology. Often the term has foreign intelligence connotations in the sense of assessing the level of some other nation's technology in comparison with our own. This, of course, has no relation to the TA being discussed here which is concerned with future impacts of the applications of a technology.

3. DEFINING THE PROBLEM AND DESIGNING THE STUDY

The first point to be confronted was the definition of the problem in terms I could cope with. This normally would involve consideration of the client's needs were this a "classic" TA. In this case, the situation was somewhat muddled. To start with, who was my client? General Daniel? Harold Davidson? The Army Staff? The truth of the matter is that I never really knew, and even more important, his needs were never communicated to me in definite terms, such as: "The Army is considering a major R&D effort in manufacturing methods using high-energy lasers as metal working devices (see Volume I, section 4). A technology assessment is needed to determine the impact that the Army's entry into this technology will have on the civilian manufacturing sector." Rather, the problem as it was stated or as I perceived it was, "As an experiment, try doing a TA in the high-energy laser field and tell us what happens. Resources are not available to do an 'all up' TA, but do the best you can."

I must emphasize that I do not intend criticism by these comments, since in a very real sense this was indeed the problem. Neither the Army nor I knew anything about TA except that we both thought it was probably a good idea and that the Army should "get its feet wet." Of course, the only way to do that was to just jump in, which is what happened. At the risk of beating the analogy to death let me say, however, that the difficulty with this approach was that I was left floundering from lack of direction. This brings me to the next conclusion of this report, which I wish to emphasize as strongly as I can. The person conducting a technology assessment **must know his client personally, must be made aware of his client's needs at the outset, and must maintain a close relationship with his client to determine if these needs change with time as the study progresses.** Only through such a relationship can the TA be altered as necessary and tailored to fit the client's needs as much as possible. However, this must not be interpreted to mean the client should dictate the results or that the TA should say what the assessor thinks his sponsor wants to hear. It goes without saying that **a Technology Assessment should be totally unbiased.** Without having this relationship first guaranteed, the prospective PM should think twice before accepting the position.

Within this context of a lack of specific goals, I attempted to formulate a design for the study. My only references were some TA's which I obtained from various sources, after which I intended to model the methodology for my study. In particular, the Mitre Study by Dr. Martin V. Jones[3] was used as a basis for my own outline. A Preliminary Plan for the HELTA was sent to Harold Davidson for record on 10 Nov. 1973. (This Plan is included in this report as appendix C.) Looking back on this plan, it appears in many respects to be extremely naive. Yet it represents a common-sense approach to the problem. At the risk of sounding immodest, I must say that I am amazed how well that original plan stood up and how closely I was able to follow it, as evidenced by my progress reports (appendix D). The intention was to break down the TA into three parts. First, I had to become acquainted with the technology itself. To accomplish this I proposed performing a literature search as a first step, and then visiting as many people and places involved with high-energy lasers

[3]Martin V. Jones et al, *A Technology Assessment Methodology*, The Mitre Corp., MTR6009, McLean, Va., June 1971.

as I could. The literature search was conducted through the HDL and National Bureau of Standards (NBS) libraries, and by retrievals from the data banks of the Defense Documentation Center and National Technical Information Service of the Department of Commerce. In all, between 150 and 200 documents were obtained. The fruits of this research turned out to be less than overwhelming, which indicated my own ignorance of the technology. Since a large portion of the information on high-energy lasers is classified, the open literature is a poor source of hard facts. Useful information **was** obtained during the search, but it went only so far and gathering all these documents turned out be be "overkill."

Another method of accumulating data on the technology was the use of a Technology Description Background Statement (Table I) which, according to the Mitre study, is a general format by which any technology can be described to organize raw data for a TA. Such a statement was prepared in blank for high-energy lasers and sent out to dozens of companies, agencies, institutions, and individuals. The response was very poor and the technique yielded little for this particular study--perhaps because those who received the statement misinterpreted its use. It is not a "form" to be filled out, but a checklist to guide one's thinking in trying to define a technology, in developing the Technology Forecast, and in developing the list of first-order impacts. Responding to such a format is a big job which needs a task force approach to do the job right, not a volunteer devoting only a few hours from his regular job. Also, the manner in which the request for information was conveyed. the very appearance of a "form" probably did not evoke a sympathetic response from the recipients. A better plan for the future might be to have a technical person directly associated with the TA study who is intimately aware of the technology and can oversee the data gathering personally.

The real sources of valuable data were the trips that John Scales and I took over the course of the study. With proper clearances sent in advance, we visited dozens of government and private installations working in the field. The result was a feel for the technology with which we were dealing, which proved to be important in taking the rest of the study in context. Thus, we come to the next point for emphasis. **A TA cannot be performed in a vacuum. If you are not familiar with the technology you are assessing, you must allocate a portion of your time and budget to that end.** Before that point sinks in too deeply, however, I must hasten to add the counterpoint, which is probably the single most important point a prospective TA'er should carry away from this report. **Don't get wrapped up in the technical nitty-gritty so that you lose sight of what you are trying to accomplish. A TA is concerned, not with what makes the technology go, but with what impacts the technology will have once it is already going.** I must credit Joseph Coates, one of the leading authorities in the field of TA, with putting me on the right track in regard to this point. I visited him at the suggestion of Dr. Goldhar to gain some insight into the problem. He cautioned me that the risk a technologist (such as myself) runs in performing a TA is concentrating on the "T" part, with which he is comfortable, to the exclusion of the "A" part, which is really most important. A technologist performing a TA must continually remind himself that at this point **TA is more art than science.**

The second part of the plan was to perform some sort of technology forecast, not only about laser devices themselves, but more importantly, regarding what the future holds in the way of applications. After all, **it is the applications of a technology, not the technology**

TABLE I

TECHNOLOGY DESCRIPTION BACKGROUND STATEMENT

MATTERS ADDRESSED	COVERAGE
1. Physical and Functional Description	What the Technology Embraces Scientific Disciplines Involved Industries Involved Professions and Occupations Involved Products Affected Design-Dimension Data Manufacturing Characteristics Including By-Products
2. Current State-of-the-Art	Current State of the Assessed Technology Current State of Supporting Sciences
3. Influencing Factors	Technical Breakthroughs Needed Technological Factors Affecting Development and Application Economic Factors Affecting Development and Application Institutional Factors Affecting Development and Application
4. Related Technologies	Complementary (Supporting) Technologies
5. Future State-of-the-Art	Timing - Initial Operating Capability Timing - Widespread Applications
6. Uses and Applications	Current and Prospective Industrial versus Consumer Markets Buyers: Age Groups, Incomes, and Geographic Distribution Marketing Channels Financing

Excerpt from M. V. Jones, Mitre Corp. M73-62.

itself, that will have the impacts on society and that must be assessed. A list of potential applications that eventually totaled 66 was collected from the literature search, from people visited during the field trips and from two brainstorming sessions held at HDL that were particularly interesting experiences and quite worthwhile. Groups of researchers from widely varying disciplines were gathered and asked to imagine what possible applications a high-energy laser device might have. Certain specifications of the device in terms of power output, size, etc. were given. The participants were asked to abide by the rules of brainstorming, which essentially require the discussion to be fast-moving and free-wheeling, with no more than a minute or two devoted to any one topic, and no negative comments about another's ideas which would tend to make the discussion less open. The results were highly gratifying. Suggestions came fast and furiously as the participants began to get involved, and it was only with difficulty that we were able to terminate the discussions after two hours. The proposed applications ranged from highly probable to barely possible. Some, as I learned later, were already under active consideration by various private companies. The conduct of the participants in the brainstorming session was spontaneous, imaginative and unbiased, since no one was specifically knowledgeable in the high-energy laser field. This leads me to another point made by Joe Coates that applies both at this point in the plan and in the third part as well: **Think broadly, do not be constrained, do not prejudge.**

At the time I drew up the preliminary plan, I had no doubts about being able to do a creditable job on the first two parts. Scientists are trained to collect data and do literature searches. However, the third part was another story. This was the impact analysis which is the heart of a TA, its most important part and the hardest to perform. In essence, the plan said, "PART III--The Impact Analysis will be carried out," since at the time I had to believe that when the time came, a light would go on and the way would miraculously be made clear. All I did know was that I would definitely need help. Through Harold Davidson I made contact with Dr. Martin V. Jones, formerly of the Mitre Corporation, and current Director of the Impact Assessment Institute. He agreed to act as a consultant for the impact analysis. His services were officially procured (after a great deal of red tape) by the Durham, N.C. Office of the Army Research Office through its Scientific Services Program. The arrangement worked well and Volume I of HELTA is the product of this cooperative effort. From this experience I have concluded that for a future TA, **between the Project Manager and his first assistant there must be some degree of expertise both in the technology and in the methodology of technology assessment.** I don't believe it is critical which of the two has which type of expertise, just as long as they interact closely with each other. One additional lesson I learned was that **consultation or expertise on the methodology to be used should be involved from the very beginning.** In the present case, Dr. Jones was not brought in until the course of the HELTA had already been established, at which point we would not have been able to make any major changes that might have been appropriate.

The final product of this TA is a three-volume report. This volume, number II, deals with the lessons learned and it was felt appropriate to set it apart from the rest of the report. The HELTA proper is contained in Volumes I and III. These two volumes result from a decision made on a problem that will be peculiar to some military TA's. TA's are inherently civilian-oriented studies and, as such, should be made available to civilian

agencies, private companies, and the public. Many technologies within the military that might be suitable topics for future TA's are classified, as was the current topic of high-energy lasers. Thus, the question becomes one of how to treat such topics. Two methods were used in the HELTA. First, recognizing that a certain amount of low level technical information should be presented in the report, I decided to publish a separate volume of classified material whose dissimination could be controlled; hence Volume III. It contains information solely about the technology and the technology forecast and is intended for those readers with proper clearances and needs-to-know. This does not really restrict the study as a whole since the client for an Army TA would be the Army itself. Second, Volume I contains a very sketchy description of the technology and the technology forecast and then goes on to the impact analysis, which is based on some qualitative "what if" suppositions. Thus, since we are talking of technology not yet developed, and which probably will not be developed for a number of years, we should be safe from the security aspect. This type of document could be released for public use.

4. RESOURCES--FUNDING AND PERSONNEL

The job of any project manager includes estimating the resources he will need, both for funds and personnel, and then obtaining them. One of the major problems encountered with the HELTA was the question of what resources were necessary and where to get them. We lacked both funds and people, but this is usually the case, no matter what the project. However, the topic of resources requires a much closer explanation than just stating that there weren't enough.

Since the funding question is the simpler one, I will begin with that. As stated earlier, one of the conditions placed on the HELTA was that the expenditures should be kept to an absolute minimum. My expenditures, which are given in Table II, totaled about $24,000. All but the $3,000 for the consultant was charged to HDL. The utilization of 0.6 man-years of a professional over the 15 months of the study, plus the consultant, come to a level of effort of 0.76 man-years. The consultant's fee came from AMC Headquarters. What did the Army get for this expenditure? Evaluation of quality aside for the moment, the product was a technology assessment and the evaluation of the methodology employed. There are three volumes totaling about 225 pages. That comes to about $107 per page. Is this a bargain, or did the Army get taken? To answer that, again considering only the form, not the substance, let us look at a short study published by Mitre entitled "A Comparative State-of-the-Art Review of Selected U. S. Technology Assessment Studies"[4] in which thirteen TA's are evaluated and compared in terms of resources used, methodologies, impact on the technology, etc. In regard to the resources, Table 3 displays a comparison of certain parameters of these 13 studies with the HELTA. The average cost was $1391 K at an average level of effort of 9.3 man-years. From the "Cost per Page" column, the HELTA seems to be a real bargain. Obviously, this is not the whole story. The 13 TA's compared in the study were all major efforts involving large multi-disciplinary teams that provided comprehensive TA's upon which specific decisions could be based. The HELTA, on the other hand, was a small effort--low budget and short term--designed to provide a general overview and perhaps spark the reader's imagination. This approach to TA has been called a "mini-assessment" and will be discussed further in the next chapter. The answer to whether the Army got its money's worth for the resources expended, or indeed, whether anyone would find such an effort cost-effective, depends on the original goals set by the client. If they wanted specific quantitative answers to a series of specific quantitative questions, then a report like the HELTA can only serve as a first step, an outline or a plan of work. If, however, the goal was to scan the subject matter briefly, uncover the possibilities, and erect a set of warning flags along the decision path of the R&D manager, then a report like this one is a steal at twice the price. One could say that you get what you pay for, but this might be a bit oversimplified. From some studies now being conducted, it appears that **the mini-TA approach may well provide information far out of proportion to its funding level.** To gain some insight into this funding issue, the National Science Foundation recently awarded two contracts for TA's on the subject of earthquake prediction technology. One went to the Stanford Research Institute for $283 K, and the

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[4]Martin V. Jones, *A Comparatve State-of-the-Art Review of Selected U. S. Technology Assessment Studies*, The Mitre Corp., M73-62, McLean Va., May 1973.

TABLE II

COST SUMMARY FOR THE HELTA

<u>Project Manager</u>	
Salary for 0.5 man-years	$10.0 K*
Travel	2.5
<u>Physicist</u>	
Salary for 0.1 man-years	2.5*
Travel	1.5
<u>Consultant</u>	
Fee	3.0
<u>Secretarial</u>	
Salary for 0.1 man-years	1.0*
<u>Miscellaneous</u>	
Purchases	0.5
Graphics, Reproduction	0.5
Printing	2.5
TOTAL	$24.0 K

*These salaries do not include additional charges for overhead, since they were charged to an overhead-funded project number at HDL. For the sake of planning future TA's similar to this one, the total cost would be approximately twice that of the HELTA.

TABLE III
COMPARISON OF TECHNOLOGY ASSESSMENT STUDIES

Study	Performed By	Date	Cost (\$K)	Number of Professionals	Duration (Months)	Length of Report	Cost Per Page (\$)
Advanced Automotive Propulsion Systems	Mittman Associates	1972-73	320	11	12	600	533
Snowpack Augmentation in the Upper Colorado River Basin	Stanford Research Institute	1972	180	20 + consultants	12	650	277
Civil Aviation	George Washington Univ	1971	236	32	12	214	1103
Televised Violence	U.S. Public Health Service	1972	1500	12	30	2000	750
Jamaica Bay and Kennedy Airport	Nat. Academy of Science Nat. Academy of Engineering	1971	350	26	12	175	2000
Metric America	Nat. Bureau of Standards	1971	1300	25	36	2500	520
Cardiac Replacement	Nat. Heart Institute	1969	150	14	12	93	1613
Forest Management in Wyoming	U.S. Dept. of Agriculture	1971	100	7	6	80	1250
Alaska Natural Resources	U.S. Dept. of Interior	1967	*	*	60	*	*
Hurricane Modification	Stanford Research Institute	1971	55	5	1[illegible]	22[illegible]	250
Use of Underground Space	Am. Soc. of Civil Engineers	1972	250	9	12	323	774
Northeast Corridor Transportation Project	U.S. Dept. of Transportation	1970	12000	9 + contractors	*	* (18 separate reports)	*
Off-Shore Oil and Gas	Univ. of Oklahoma	1973	250	8	20	660	379
Averages			1391	[illegible].2	19.7	578	859
High Energy Lasers	U.S. Dept. of the Army	1974	24	.6 + consultant	15	225	107

*Data not available (not figured in averages)

other to the Impact Assessment Institute for \$22 K or less than 8 percent of the larger study. The work is not yet finished, but the final results should prove interesting. Is it possible that a large percentage of the basic knowledge gained in a TA can be obtained with the first small increment of funds, using the remaining funds mainly to expand, to go into greater detail, and to extend the quantification? This dual study might provide the answer.

However, lest the reader be left with the notion that the smaller the funding the more impressive the results, I want to emphasize again that HELTA was underfunded to the point that a full set of even the most general conclusions could not be drawn. An example of one problem I had was in the failure to obtain a mere \$3 K additional funds to have a two-week study performed by one institution. The information obtained was to have been concerned firstly with the absolute limitations of laser technology imposed by the laws of physics which would have set a frame of reference for the technology forecast. Secondly, a translation of laser technical parameters such as energy delivered were to be translated into terms having commercial significance such as inches of stainless steel cut per second. This information would have enabled at least a preliminary polling of certain industries for impact of the technology. Such a study would have added great depth to the HELTA at a very small additional cost.

The topic of resources other than fiscal is a little more involved, but is one of the more crucial points that will determine whether, or how, the Army will perform future TA's. What is required to perform a TA in general is an interdisciplinary team composed of economists, sociologists, ecologists, lawyers, industrial engineers, and, of course, some people knowledgeable in the specific technology being assessed. Someone conversant with the techniques of TA is also necessary. As project manager it was my job to gather these people together while working under the constraint that, by and large, only in-house personnel should be used. John Scales and I represented the technical "expertise" and Marty Jones was the source of the methodology. That was the extent of the "interdisciplinary" team, for it seems that the Army is not well endowed with "soft" scientists such as sociologists. Sure, there is an economist or two floating around in the Army system, but try to find them! And if you do find them, try to get them, or their agency to donate their time. The closest thing I could find to such a resource was the Army Research Institute in Arlington, Va. However, these people were more concerned with the behavioral sciences involving such problems as the effect of various parameters (diet, types of clothes, etc.) on the performance of the individual soldier. We explained our problem to the ARI but could not find any common ground for them to come into the project. From futile efforts such as this to obtain help, I have concluded that **more than likely, the Army must go out-of-house for the social science resource personnel for any future TA's, especially comprehensive ones.** The technical personnel can be found in-house or in an in-house/contractual partnership. However, **it will be necessary to keep some in-house personnel involved with the study to maintain the appropriate direction for the Army's purposes, and to protect the Army's interests in relation to the contractor's.**

What resources were available but not used? Looking back over the past year, this is still a very difficult question to answer. From the technology standpoint, fairly good use was made of what was available: labs were visited, scientists were interviewed, etc. However, there was a certain lack of direction to the problem as I indicated earlier, which may have been due in part to the ambiguous nature of the client's needs. Also, the acknowledgement from the outset that this was to be a low-key effort probably hampered us psychologically from thinking on a large scale. One resource that might have been available was the Army Scientific Advisory Panel (ASAP) which could have been used as a steering committee of eventual users of the report. This would not be an oversight committee, but rather an aid to the project manager to help formulate the approach, suggest resources, and keep the project up-to-date on possible changing requirements.

Another area in which I looked for help was the Technology Assessment Panel of the Engineers' Joint Council. The EJC is an umbrella organization that takes in such organizations as the IEEE, ASME, SAE, and many others. The EJC/TAP was a new subgroup organized to explore and utilize TA for the benefit of the member societies. At the time I approached them they were about one year old and had been looking for a project through which to gain some experience. The situation looked like a natural. It wasn't! Again, lack of time and resources (both funds and personnel) prevented the coordination and use of this potentially valuable source of information. Nor was the EJC/TAP able to muster any large-scale volunteer efforts on my behalf.

To summarize this whole question of resources, let me reiterate some points made earlier. We started with the assumption that all the talent needed could be found within the Army without cost. As far as we could tell, this turned out to be a bad assumption. If there are such people, no one seemed to know where they could be found. If they could be reached they would more than likely be committed to other work and/or couldn't be afforded. Also there might be training and interest problems. Thus, the people must be gotten from the outside with all the problems (e.g., security) and expense that that entails.

5. METHODOLOGY

In this chapter I wish to discuss (1) the way the HELTA was done, and (2) the alternative ways it could have been done. To begin with, I have already noted the initial steps taken in getting the state-of-the-art of the high-energy laser technology, and the first step in the technology forecast, namely gathering a list of possible future applications. This part was straightforward and simple, and requires no prolonged discussion. The next step that could have been taken was to complete the technology forecast by adding quantitative date as to future device parameters (power levels, efficiencies, sizes, etc.) and applications parameters (market penetration predictions, competitive technologies, time phasing of applications, etc.). Such information would be the next logical step in a comprehensive TA, but a full-blown technology forecast can be a major project in its own right. There are dozens of methodologies and techniques for forecasting which can be called on.[5] However, this course of action was clearly beyond the capabilities of this effort. Thus, we took the course of assuming that eventually the technology would become as widespread as necessary to support the rest of the study. Does this action become a fatal flaw in the study? Only if one wishes to continue with the impact analysis on a quantitative basis. However, as I mentioned earlier, this was not the aim of the HELTA. After reviewing some of the existing TA's such as a massive one done for the Maritime Commission by United Aircraft Research Laboratories on Ocean Shipping[6] which was in seven volumes and stood three feet high(!) I quickly came to the conclusion that there was no possible way for me to equal such a feat. Enter Marty Jones to the rescue. Marty, as well as being one of the leading experts on TA methodology, is somewhat of an advocate of the mini-assessment or mini-TA. This might be defined as a heuristic approach to TA. No numbers are given, no quantification is indulged in, and no "specific" decisions can be made based on it although general conclusions might be drawn. However, it can serve the extremely useful purpose of raising the questions that need to be answered. It can be a very inexpensive and quick-response-type of document. It can stimulate a decision-maker's imagination, and it can prod the creativity of the R&D manager. As I described a Technology Assessment in volume I, it can plant warning flags along the way so that as a program director reaches a critical decision point, he is compelled to stop and think through the impacts his decision might have. Impacts not in the sense of whether a nickel-plated screw would do the job better than a chrome-plated screw, but whether--if the choice is nickel plating--the chrome-plating industry will suffer economic devastation with the accompanying economic chaos in the locality and demographic shifts out of the area, or will the increased growth of the nickel-plating industry wreak havoc on the environment by the increased effluents of the plating plants?

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[5]See, for example: Joseph P. Martino, *Technology Forecasting for Decisionmaking*, American Elsevier, New York (1972).

[6]A. Wade Blackman et al, *U. S. Ocean Shipping Technology Forecast and Assessment*, Final Report, M-971623-16, United Aircraft Research Laboratories, East Hartford, Conn., February 1974.

It was decided that the way to proceed was through the concept of the mini-TA. The structure of such a report is essentially the outline of a comprehensive TA. It contains all the steps; it shows what should be done if a more complete TA were to be attempted; it gives only preliminary quantitative analysis, but it does briefly treat an example or two. This is what was done in the HELTA, as can be seen in Volume I. The actual methodology is based on the landmark TA methodology study conducted by the Mitre Corporation under Marty Jones' direction.[3] The seven major steps as laid out in the study are given in Table IV. The sections of Volume I that represent the last three of the seven steps in Table IV are sections 6, 7, and 8. They are slightly fleshed-out versions of the statements of each step with a few examples of what would be done in a comprehensive TA.

Am I satisfied with the HELTA? Yes and no! YES, in that in my (admittedly biased) opinion, the HELTA represents a mini-TA that compares favorably with other such studies, expecially considering that it was intended to be limited to a learning experience. It does fulfill the objectives of outlining the subject matter, and hopefully raising sufficient questions in the mind of the reader that might prompt him to seek further information were he to be in a decision-making position with regard to high-energy lasers. NO, in the sense that I felt frustrated by not being able to do more in the quantitative analysis department. (I suppose that is itself an indication of the success of the mini-TA approach. I have a desire to learn more now that the way has been pointed.) At this point I should discuss what I would have done differently had I not been resource limited. But first, one more word on mini-assessments is in order. Is a mini-TA appropriate for any topic? Or for that matter, is a comprehensive TA? Probably no, for both. Joe Coates has broken up the types of TA's into three classifications.[7] One extreme is the project-oriented TA which focuses on some specific application of a technology such as the Army's use of herbicides in Viet Nam. This type of assessment, while perhaps not necessarily easy to perform, is certainly easy to conceptualize. It is well defined or bounded, and a comprehensive TA can be performed without any major methodological stumbling block, whereas a mini-TA might not yield any information of value. On the other extreme is the problem-originated TA which tends to focus on large pervasive societal problems to which the application of one or more technologies may be considered as possible solutions. An example might be the Volunteer Army. Such a question is inherently unbounded and a mini-TA might be the only way to approach it without making a quantum jump to the astronomical expenditures of resources that would be necessary for a comprehensive treatment. In any case, the mini-TA would be absolutely vital as an organizational tool for a larger treatment. Then there is the middle ground, the technology-originated TA, which focuses on a specific technology but not on any specific application. This type of study, like all things that are neither fish nor foul, is the hardest to get a hand-hold on, to decide exactly where to set the bounds, to pick a starting point and a direction to move in. Here, both the mini-TA and

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[3] Martin V. Jones et al, *A Technology Assessment Methodology*. The Mitre Corp., MTR 6009, McLean, Va., June 1971.

[7] Joseph Coates, *The Identification and Selection of Candidates and Priorities for Technology Assessment,* Technology Assessment, 2, No. 2 (February, 1974) p. 79.

TABLE IV

SEVEN MAJOR STEPS IN MAKING A TECHNOLOGY ASSESSMENT

STEP 1	DEFINE THE ASSESSMENT TASK Discuss relevant issues and any major problems Establish scope (breadth and depth) of inquiry Develop project ground rules
STEP 2	DESCRIBE RELEVANT TECHNOLOGIES Describe major technology being assessed Describe other technologies supporting the major technology Describe technologies competitive to the major and supporting technologies
STEP 3	DEVELOP STATE-OF-SOCIETY ASSUMPTIONS Identify and describe major nontechnological factors influencing the application of the relevant technologies
STEP 4	IDENTIFY IMPACT AREAS Ascertain those societal characteristics that will be most influenced by the application of the assessed technology
STEP 5	MAKE PRELIMINARY IMPACT ANALYSIS Trace and integrate the process by which the assessed technology makes its societal influence felt
STEP 6	IDENTIFY POSSIBLE ACTION OPTIONS Develop and analyze various programs for obtaining maximum public advantage from the assessed technologies
STEP 7	COMPLETE IMPACT ANALYSIS Analyze the degree to which each action option would alter the specific societal impacts of the assessed technology discussed in Step 5

the "all up" are appropriate, with the mini serving the role of the preliminary, the ground-breaker, with the comprehensive TA to follow if the results of the mini-TA so indicate. The HELTA was, of course, a technology-oriented TA.

As to what could have been done otherwise, of course the first thought is to have done the comprehensive TA. Starting with the technology forecast, this aspect could have been broadened by performing a survey of experts in the field, using questionnaires to gather their opinions as to how and when high-energy lasers would reach certain technological levels of accomplishment. For example, a Delphi might have been run. The greatest expansion, however, would have come in the impact analysis. Panels would have been assembled, either physically or through the mails consisting of members of relevant disciplines (i.e., impact areas such as manufacturing engineers) and representatives of impacted groups (e.g., automotive labor unions) for many of the applications cited in section 4 of Volume I. Each pair of panels would discuss the possible impacts of the particular applications with which they are concerned. Quantitative projections would be made and sets of matrices would be drawn up such as those shown in Table V. These statistics would be processed to yield a cost-benefits analysis of each application

TABLE V.

IMPACT ANALYSIS MATRICES

(one for each application being analyzed)

IMPACT AREAS

IMPACTED GROUPS	Economy	Safety	Social	Environmental	Technology . . .
Family					
Community					
Labor					
Federal Government					
Military					
Minorities					

considered. In addition, multi-disciplinary study panels would convene to draw up flow charts such as that shown in Figure 20 of Volume I (reproduced here as Figure 1). These flow charts, however, would be augmented by probabilities and time-phasing of the various possible paths. In short, the mini-TA that was done concentrated on gathering some data and doing some analysis on an illustrative basis. A followup with a comprehensive TA would allow considerably more analysis of the data and indeed generation of new data unavailable for the low level of effort mini-assessment. One such panel was convened for the HELTA and was attended by some of the leaders in the TA field. The results were somewhat questionable though, probably because I didn't really know what to expect from such a group. There was a lot of discussion about motivation and methodology, but the actual topic of the impact of high-energy lasers was only discussed in the most general terms. Some useful information on TA methodologies was gained, but no real contribution to the HELTA, per se, was made.

Following the analysis, the conclusions, in the form of action options, would have been presented. What I would have done here depends to a large extent on what type of relations with the client I had. That is, **before I can suggest action options, I must find out what questions the client needed resolved.** If it was a specific question concerning the impact of a particular application like metalworking, then the whole TA would concentrate on that one application only. (This, of course, would be a project-originated

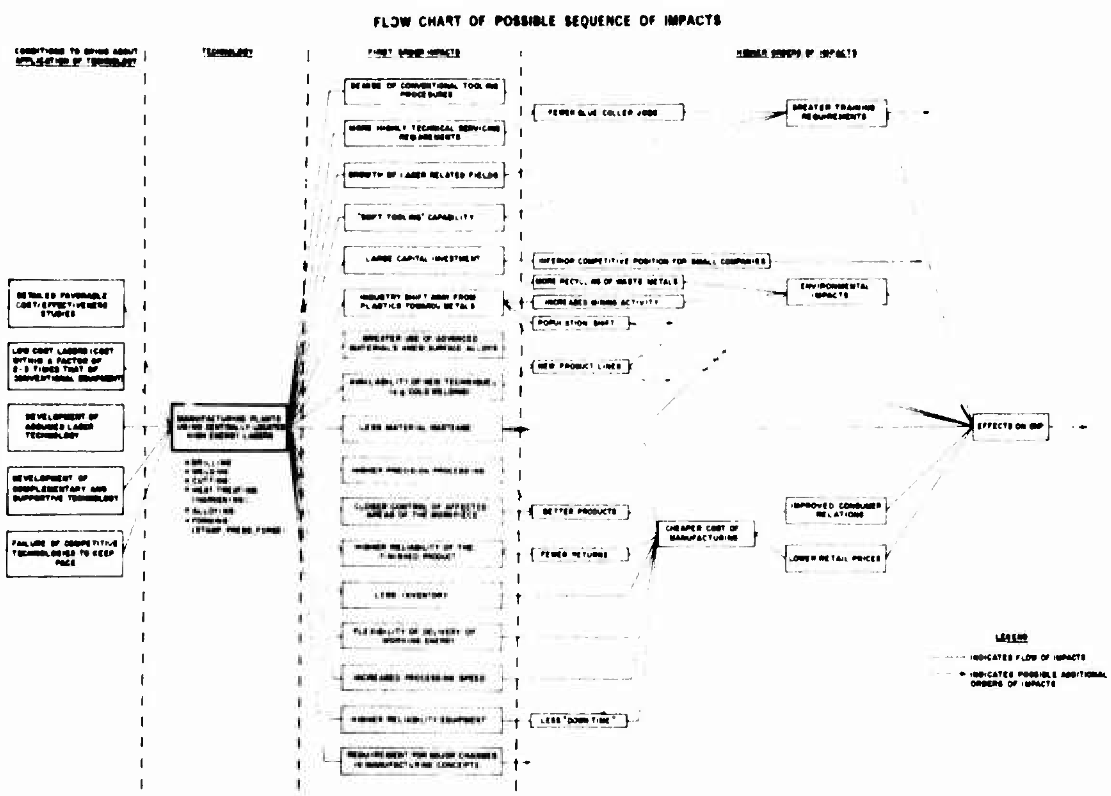

Figure 1.
Application of High-Energy Lasers to Manufacturing

TA.) If it was a technology-originated problem like "What are the impacts of the next application after weaponry that the Army should consider for high energy lasers," then a broader study would be made with an appropriate action options suggested, again on a quantitative basis of costs (fiscal, material, and non-material) versus benefits.

A related facet that the client would have to communicate to me is **what type of policy decision is pending on the outcome of the TA.** (I hope that does not sound too pretentious, but presumably, the only reason the study would be ordered is if there was a decision to be made for which additional data were required.) Is the decision to be of the "GO-NO-GO" type; or, if the technology is already "GO," is the decision concerned with what constraints, redirections, or accelerations are appropriate?

Finally, one more question concerning action options is, **would the outcome of the study change in relation to the amount of work done on the TA?** Would a six-month, $200 K study yield a different set of conclusions than a one-year, $1M study? This question can not be answered at this time without further TA methodology research.

To summarize then, we did think out in advance what we would like to do in HELTA, but we found we could not do it for two reasons. First, there were resource limitations; second, there was poor communication with the client. However, the methodology of the mini-assessment was certainly appropriate for this TA. But I must emphasize, if my client is happy with the results, then he must understand that **what was done with the HELTA as a learning experience will not work again in a real situation where action options are required. Resources must be adequate and client needs must be clearly and continuously defined.**

Additional thoughts by Joe Coates on technology assessment are presented in appendix E.

6. CONCLUSIONS

This volume has been written with the intent of giving the R&D manager some feeling of what the performance of a TA might involve. It is based on my own experiences and opinions. There is no point in recapping the points I have already made, since they have been highlighted in the text. However, there are a few additional considerations.

Will the Army ever do a full-scale assesment? Yes, if pressure from the Office of Technology Assessment is felt either directly or indirectly. Probably no, if the impetus for such a study must be originated internally. As indicated by Table III, comprehensive TA's are major undertakings. Considering the situation and the Army's customary habit of reacting rather than acting, the probabilities are slim. The fact of the TA's usefulness as an R&D management tool probably will not carry that much weight. However, the Army must realize that it will always bear a certain responsibility for any negative impacts that its technology development may have.

Be optimistic for a moment and assume that the Army decides to utilize the advantages offered by TA. Should the Army then maintain an in-house capability or rely solely on external contracts? I have already expressed my view on this earlier, that by and large, the "soft science" capability is not available within the Army and, therefore, would have to be procured elsewhere. The "hard science" capabilities do exist and should be used in a combined in-house/out-of-house team. Should a permanent staff be maintained? There are certainly some economy-of-scale benefits that could be considered but the risk of institutionalizing TA into a new bureaucracy must be contended with. It probably is important, though, to maintain a small staff of two or three professionals who are "plugged into" the TA system and have them report at the top of the R&D command chain. At least in this way some talent will always be available. However, it would probably be difficult to justify the recruiting and retention of a large interdisciplinary team of high-level professionals with talents not usually found within the Army system such as sociologists. That is, it would be difficult unless the Army decides to commit itself to TA in a very big way. One of the serious problems that I encountered was that I was not "plugged in;" and of all the Army people I dealt with, the only one that was to any extent was Harold Davidson.

In the event that some form of TA "group" be established in the Army system, a couple of points should be remembered. It is vitally important that such a group be completely independent of the agency developing the technology being assessed, and report directly to an equal or higher level of command, preferably to the Chief or Deputy Chief of Research, Development and Acquisition. The right to publish all TA's in the open literature should be guaranteed. Naturally classified data would be exempted from this, and the familiar caveat about the views expressed not necessarily representing the official Army position could be included.

Let me go one more step in this general area. Section 3 notes the importance of the clients' needs being made clear to the assessor, but that client influence or pressure

should not tilt the outcome of the TA toward one set of conclusions or the other. Enlarging upon this thought, the following quote is particularly appropriate.[3]

> "...technology assessors should--*must*--take a much broader view of their responsibilities ... than that of a lawyer who has been hired simply to defend the interests of a litigant. In effect, they should say to the funding agency ... 'When you hire me, you inevitably get more than you bargain for. My professional obligations require me to consider not only your interests, not only the criteria you believe to be important and relevant, but also a great many other factors, including some that you may not have thought of and may not even care about. My clients are all the affected groups in society, including some who may not even know they are clients; and some of them may have interests that conflict with your own. My findings may lead to the conclusion that your innovation ought to be abandoned even though it would be beneficial for you. That risk is part of the price you must pay for getting any objective assessment of your innovation at all'."

Finally, the careful choice of topics is important. This is the problem that the OTA has been wrestling with since its inception. The choice of too ambitious a topic could doom the TA to failure and necessitate superficiality in the treatment; too narrow a topic could result in the charge of triviality being leveled. Topics should be appropriate in terms of doability, level of urgency, and the commitment to act on them when completed. Perhaps a good way to start a TA program would be to consider technologies not too far in the future. For example, a technology or a system that is due to achieve initial (as opposed to widespread) application within the next two or three years might be a suitable topic. The question to be answered might be "When it gets here, what impact will it have, especially if the technology is transferred to the civilian sector."

R&D planning has been growing more and more complex and will continue to do so. If the OTA becomes a real asset to the Congress such as the GAO has become, we will find that TA within the government will become more prevalent. This includes the Army. For both these reasons, some level of Army capability in TA is liable to become a necessity. It will not come cheaply or easily. As Professor Raymond Bauer put it:[8]

> "How does one carry out technology assessment? I suppose that at this stage the problem is akin to that of how one can eat an elephant. The only answer is that one must begin by biting the elephant. And, considering the magnitude of the task, it is difficult to argue that one place is better than another for the biting to start. And, after a considerable amount of biting has taken place, the elephant remains largely unscathed--I fear."

To which I can only add, if one is hungry enough . . . .

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[3]Robert Feldmesser as quoted in Martin V. Jones et al., *A Technology Assessment Methodology*, The Mitre Corp., MTR 6009, McLean, Va., June 1971, p. 30.

[8]Raymond Bauer, *Second-Order Consequences: A Methodological Essay on the Impact of Technology*, MIT Press, Cambridge, Mass., 1969, pp. vii-viii.

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APPENDIX A

PROJECT MANAGER CHARTER

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APPENDIX A

PROJECT MANAGER CHARTER

HIGH-ENERGY LASER TECHNOLOGY ASSESSMENT

A-1. DESIGNATION OF PROJECT MANAGER

Dr. Edward A. Brown of the Harry Diamond Laboratories is designated Department of the Army Project Manager for the High-Energy Laser Technology Assessment effective this date. Dr. Brown assumed project responsibility effective 2 October 1973. The Project Manager reports to the Director of Army Research, Office of the Chief of Research and Development.

A-2. MISSION

The Project Manager is responsible for project management of the High-Energy Laser Technology Assessment in accordance with DARD-ART Letter dated 10 Sep 1973 and all pertinent regulations.

A-3. AUTHORITY AND RESPONSIBILITY

The Project Manager is delegated the full line authority for centralized management of his specific project, and is responsible for planning, directing, and controlling the allocation and utilization of all resources authorized for execution of the approved project. He is responsible for designing the assessment, determining the resources necessary to carry out this effort, and directing the project through its completion. The Project Manager is supported by offices and organizations within AMC and other participating organizations, identified in Section A-4.2, which are responsible to the Project Manager for the execution of specifically assigned project tasks.

A-4. INTERFACES AND PARTICIPATING ORGANIZATIONS

A-4.1 Interfaces

- Director, Defense Research and Engineering.
- Atomic Energy Commission.
- Department of the Army.
- Department of the Navy.
- Department of the Air Force.
- Private Industry, as appropriate.
- Foreign Governments, as required.

A-4.2 Participating Organizations

- US Army Missile Command--Supports the project office in gathering data related to high-energy lasers.
- Harry Diamond Laboratories--Provides functional and administrative support.
- Contractors--Provides project office with support in the area of Technology Assessment methodology as required.

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A.5. COMMUNICATION CHANNELS

A.5.1 The Project Manager has a direct channel of communication to the Director of Army Research, should any of the participating organizations fail to respond to project requirements in any of the several management areas.

A.5.2 Direct communication is authorized between all participants involved in implementation of the approved project to assure timely and effective direction and interchange of information between participants.

A-6. RESOURCE CONTROL

Departmental resources, pertinent to assigned missions will be provided directly to the Project Manager by Military Interdepartmental Purchase Request (MIPR).

A-7. LOCATION AND SUPPORT

The High-Energy Laser Technology Assessment Project Manager's Office is located at The Harry Diamond Laboratories, Washington, D.C., where necessary facilities and administrative support are being provided by that organization.

A-8. TRANSITION

Current plans call for the completion of the project during second qtr, FY75. Upon completion, the original and an appropriate number of copies of the High-Energy Laser Technology Assessment will be delivered to the Director of Army Research. This document will include an unclassified executive summary.

A-9. SPECIAL DELEGATIONS

Dr. Edward A. Brown, has been delegated the full-line authority of the Director of Army Research, for the execution of the High-Energy Laser Technology Assessment mission within the terms of this charter.

APPROVED: /s/ H.F. Davidson DATE: 1/14/74

CRD Project Monitor

APPENDIX B
DRAFT LETTER OF INTRODUCTION

DARD-ART

SUBJECT: High-Energy Laser Technology Assessment

1. Reference: Technology Assessment Act of 1972, Public Law 92-484.

2. Technology Assessment (TA) is the evaluation of the secondary physical, environmental, social, economic, and political effects of technological applications. The above-referenced act established the Office of Technology Assessment for the Congress as an aid in the identification and consideration of the probable impacts of the application of a new technology. This lends a greater importance to TA as a management tool in helping key R&D managers decide which programs to promote by indicating possible beneficial as well as detrimental side effects.

3. The Army believes that TA is a worthwhile endeavor for any R&D organization. It also anticipates being called on by Congress in the future to perform technology assessments on new programs it is proposing. For these reasons the Office of the Chief of Research and Development has undertaken a pilot TA which will serve important management learning objectives in addition to providing the appropriate analysis. The subject of the pilot study will be High Energy Lasers.

4. Dr. Edward A. Brown of the Harry Diamond Laboratories, Washington, DC is the assigned Project Manager for this effort. Dr. Brown's study will take approximately one year during which time he will survey the current state-of-the-art in the high energy laser technology, make a determination as to present and future applications, and then perform the TA in relation to these applications.

5. Dr. Brown would appreciate the opportunity of visiting your organization in the near future as it represents a center of excellence in one or more facets of the high energy laser technology. Any help or cooperation which you can provide to him will be greatly appreciated. It would be particularly useful if you would designate a point of contact and have him, at his earliest convenience, contact Dr. Brown at 202-282-2028 (Autovon 292-2028), in order to expedite the proposed visit.

FOR THE CHIEF OF RESEARCH AND DEVELOPMENT:

Signed

CHARLES D. DANIEL, JR.
Major General, GS
Director of Research and
Advanced Systems

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APPENDIX C

PRELIMINARY PLAN FOR HELTA

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APPENDIX C

PRELIMINARY PLAN
FOR
HIGH-ENERGY LASER TECHNOLOGY ASSESSMENT [HELTA]

This document provides a rough outline of the procedure that will be followed in carrying out the HELTA. The objective of the HELTA is to assess the higher order impacts (both positive and negative) of the applications of the technology of high energy/power lasers. "Higher order impacts" will be taken to mean impacts on areas other than the technology itself. Such areas could include the environment, the economy, the social and legal systems. "Applications" will center to a large degree on military applications, but will not be limited to these only. For instance, it is envisioned at this time that the assessment will be concerned with applications dealing with the generation of power by thermonuclear fusion which, while not specifically a military application, is presently of great national interest. The terms "high energy" and "high power" will not be defined now. This definition is somewhat elusive even among those practicing within the technology, and thus will not be specified until a certain amount of the raw data base has been collected.

This is the first TA that will be done specifically by and for the Army. It will serve two purposes, the first being the assessment of the high-energy laser technology itself. This is a burgeoning field that does now, and will continue to, require ever increasing support, both fiscal and political, in order to reap all the technological benefits it contains. To obtain this support, the higher order impacts of this field will sooner or later be called into question.

The second purpose to be served by this TA is to gain a familiarization with the methodology of technology assessment. With the establishment of the Office of Technology Assessment by Congress, it is only a question of time until the Army is requested to perform a TA on some subject over which it has cognizance. Thus, the HELTA will provide a proving ground in which a TA can be performed without external deadlines to meet, and where mistakes can be made and profited from. The exercise will result in a set of mechanisms, procedures, and trained individuals, which can be activated in response to a Congressional TA request on any subject.

The HELTA will be carried out in two parts. The first part will be the gathering and reducing of the raw data upon which the assessment itself will be done. A survey of the state-of-the-art will be made by the Project Manager, utilizing other personnel who are considered competent in the field and who are available to contribute some of their time. The plan for gathering the data begins by tapping all local sources in order to orient the project without a large expenditure of time and money. Such sources will include the data bank at the Defense Documentation Center, the Naval Research Laboratories, Foreign Science and Technology Center. From these interviews, a basic picture of the high-energy laser field should become clear including leads to other sources of information. After digesting the data gathered locally, the survey will be expanded to include the Eastern United States (e.g., MIT and Avco in Boston, MICOM in Huntsville, etc.) and then the Western United States (e.g., Hughes, Kirtland AFB, etc.). Finally, if indicated, foreign travel will be undertaken.

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During and after the gathering of what is hoped to be a reasonably good picture of the state-of-the-art, a technology forecast will be done which will project the state-of-the-art 10 to 25 years into the future. The forecast will be done partially during the data gathering interviews. Another scheme presently under consideration will be the performance of a Delphi-type of inquiry amongst a panel of "experts" who will be chosen as a result of the interviews.

This technology forecast will focus on the predicted applications of high-energy lasers. As soon as a clear picture of what the projected set of applications will be (including technology transfer between the military and civilian sectors), part two of the HELTA will commence. This is the actual TA. For this part, the project manager will seek the help of persons knowledgable in the TA field to determine the appropriate methodology and then to apply it. Essentially it will be a "project managed" effort with experts in each relevant impact area contributing a definitive impact statement.

In summation, an outline of the above proposal can be drawn up as follows:

I. **GATHER AND PROCESS RAW DATA**

Gather data by interview

- Locally--DDC, NRL, FSTC, AEC, etc.
- Eastern Seaboard--MIT, Bell Labs, Avco, etc.
- Eastern U.S.--MICOM, etc.
- Western U.S.--Hughes, Kirtland, Sandia, etc.
- International--Canada, France, etc.

Perform Technology Forecast

Reduce data to a set of projected applications

II. **TECHNOLOGY ASSESSMENT**

Determine methodology to be used.

Perform TA: Identify impact areas; experts prepare impact statements; peer review and inter-area considerations; condensation and interpretation of impact statements.

It is anticipated that Part I will take at least three or four months and the Part II will take about twice as long. Until some work is begun, it is difficult to make a more precise determination of the time required. The support of the Project Manager's time will be carried by Harry Diamond Laboratories and will include most of his travel around the Eastern U.S. The Office, Chief of Research and Development (OCRD) may be called on to support additional travel when and if it becomes necessary. Personnel from other government agencies will be supported by their own organizations but will require, in some cases, directives from OCRD and AMC. No commitments of any sort will be made to, or extracted from, any source in the private sector.

During Part II of the HELTA, consultants from within the government (e.g., NSF) will be supported by their own agencies. It may, however, be necessary to employ a private consultant on a part-time basis. OCRD would be requested to support this action.

Periodic progress reporting to OCRD will be made by the project manager on a roughly bimonthly schedule.

APPENDIX D
HELTA PROGRESS REPORTS

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14 February 1974

High Energy Laser Technology Assessment [HELTA]
Progress Report No. 1
Covering the period: 2 October 1973 - 13 February 1974

1. Assignment as PM-HELTA concurred in by Commanding Officer, Harry Diamond Laboratories, in 2nd Indorsement dated 2 October 1973 to 10 September 1973 letter from DARD-ART.

2. Since that time the following actions have occurred:

a. The technical and administrative scope of the HELTA was determined with Mr. Davidson (DARD-ART) and a preliminary plan was submitted on 19 November 1973.

b. A search of the DDC data bank for pertinent Work Unit Summaries was requested and received on 11 November 1973.

c. Advanced Materiel Concepts Agency was visited on 27 November 1973 to determine if their preliminary work on Technology Assessment Policy for AMC could contribute to the HELTA.

d. Dr. R. B. Watson, Director of the Physical and Engineering Sciences Office (DARD-ARS-P) was visited on 13 December 1973. Dr. Watson provided a list of points of contact within the DOD laser community.

e. Dr. John L. Scales, III of Harry Diamond Laboratories has been retained at a rate of one-quarter time to assist in the gathering of the data base and the writing of the state-of-the-art and technology forecast statements which will serve as input to the HELTA.

f. Three days of study have been spent at the library of the National Bureau of Standards, Gaithersburg, Md. in order to become better acquainted with the open literature in the field of high energy lasers.

g. Met with Dr. Martin V. Jones, formerly of Mitre Corporation, on 22 January 1974 to discuss the possibility of his becoming a consultant to the PM-HELTA for the technology asessment phase of the study.

h. Traveled to MICOM with Dr. Scales on 11 February 1974 to confer with members of the High Energy Laser Program Office staff. The state-of-the-art in HEL was discussed.

3. The present status of the program is as follows: A familiarization with the HEL field has been achieved and a start has been made in collecting the data base upon which the actual TA will be performed. A draft "Technology Description Background Statement" was

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drawn up at the suggestion of Dr. Jones after his published example.[1] (A copy of this draft statement is attached.) This statement will be passed out to those people who are contacted by this office during the gathering of the data base. They will be asked to enlarge, comment upon, or make corrections to the technology description. From their responses, a combined statement will be constructed.

4.a. Immediate plans include visits to the following organizations:

New England:	Lincoln Laboratory Avco Everett United Aircraft
West Coast:	Hughes Aircraft Hughes Research Laboratory Rocketdyne TRW
Florida:	Pratt and Whitney

b. In addition, the Air Force, the Navy and the AEC are being contacted to arrange visits to their installations.

c. A formal request is being made through ARO to hire Dr. Jones as a consultant.

5. Requirements: While the salaries for the HDL personnel are being carried on HDL laboratory overhead, there are certain expenses for which funding from OCRD is requested:

a.	Fee for consultant	$3000
b.	Travel expenses for HDL personnel (est.)	2000
	Total	$5000

(Note: The figure given for travel expenses is only an estimate. The final figure may be less, in which case the unused portion would be returned, or more, in which case additional funds would be requested. The final amount required would depend on the number of trips taken which cannot be determined at this early stage of the study.)

6. An additional comment should be made in order to put the level of effort of this study in perspective. In a survey[2] of thirteen TA's done by both government and private industry, Dr. Jones compares the techniques used, the objectives of the studies, and the resources needed. The following table summarizes the resources and compares them to the planned effort for the HELTA:

Thirteen TA's[2]

Duration	.5 - 5 years, average 1.6
Participation	5 - 32 professionals, average 15
Cost	$55 K - $1500 K, average $426 K

HELTA (Current Estimate)

Duration:	1 year
Participation:	2 professionals plus consultant
Cost:	¾ man-year plus expenses $35 K

EDWARD A. BROWN
Project Manager
HELTA

1 Jones, Martin V., *A Technology Assessment Methodology*, Vol. 1, "Some Basic Propositions," The Mitre Corporation, MTR 6009, June 1971, p. 46.

2 Jones, Martin V., *A Comparative State-of-the-Art Review of Selected U. S. Technology Assessment Studies*, The Mitre Corporation, M73-62, May 1973, pp. 13-25.

26 April 1974

High Energy Laser Technology Assessment (HELTA)
Progress Report No. 2
Covering the period: 14 February 1974 - 25 April 1974

1. During the period covered by this report the following trips were taken to gather the data base to be used in performing the HELTA:

a. 11-14 March - Southern California

Rocketdyne - Chemical Lasers (CL)
WINCON 74 - Winter Conference of the IEEE on HEL
Hughes Aircraft Co. - Electric Discharge Lasers (EDL)
TRW - CL's
Hughes Research Labs - Advanced concepts

b. 25-26 March - New England

Lincoln Labs, MIT - Propagation, laser radar
Avco Everett - EDL's, commercial applications
MITRE - HEL documentation
United Aircraft - Commercial applications

c. 4 April - Naval Ordnance Laboratory

d. 14-19 April - Southwest, Northern California, Florida

Los Alamos - laser fusion, isotope separation
Air Force Weapons Lab - HEL tech forecast
Sandia - laser fusion
Lawrence Livermore Laboratory - laser fusion, isotope separation
Pratt and Whitney - Gas Dynamic Lasers (GDL)

2. In addition, the following items were performed:

a. CPT Wilson, the Navy PM was briefed on the HELTA and his cooperation was promised.

b. . one hour meeting with Martin Jones was held for consultation.

c. Joe Coates of NSF was visited for suggestions as to how to proceed. One of his suggestions was to gather together people of varying backgrounds and hold brainstorming

sessions to come up with a list of possible future applications for HEL. A trial session was held with eight professionals from Harry Diamond Laboratories participating. The results were most gratifying. Over one and one-half hours, more than 25 applications were suggested. This procedure will be carried further by making contact with the Engineering Joint Council/Technology Assessment Panel on 7 May 1974 and requesting their assistance in organizing more such sessions.

3. The present status of the program is as follows: The data base for the HELTA is almost complete. The HEL field has been surveyed, most of the large machines have been seen, most of the people who are most deeply involved in the field have been interviewed. A large quantity of printed information from various sources has been obtained.

4. Plans for the next reporting period include the following:

a. Completion of the data base to include visits to NRL, KMS Fusion, Battelle (Columbus), Exxon, DIA/CIA/FSTC.

b. The data base with a technology forecast will be written by Dr. Scales.

c. More brainstorming sessions on HEL applications will be held with the help of the Engineering Joint Council.

d. The applications list will be scanned for candidates for impact analyses; the method of conducting the impact analyses will be decided upon.

5. One problem area exists; that of the hiring of Dr. Jones as consultant to the PM-HELTA. While the funds exist and the security clearance can be obtained, the actual hiring process has become entangled in the bureaucracy. Help is needed and requested from OCRD in alleviating this situation.

E. A. BROWN
Project Manager - HELTA

8 July 1974

High Energy Laser Technology Assessment [HELTA]
Progress Report No. 3
Covering the period 25 April 1974 - 8 July 1974

1. During the period covered by this report the following trips were taken to gather the data base to be used in performing the HELTA:

   a. 30 April - Germantown, Md.
   Joint DOD-AEC Exchange Briefing

   b. 17 May - DIA

   c. 29-30 May - Michigan/Ohio
   KMS Fusion Inc.
   Battelle Columbus Laboratories

   d. 4 June - New Jersey
   Exxon Research and Engineering Company

   e. 20 June - Dayton, Ohio
   FTD, Wright-Patterson Air Force Base

   f. 3 July - CIA

2. A presentation was made to the Engineers Joint Council/Technology Assessment Panel on 7 May 74, to enlist their support. It does not appear at this time that very much will come of this.

3. The various problems in the hiring of Dr. Jones have been overcome and he is now working on the project. So far he has prepared a rough outline of the shape the final report will take. A first draft of Chapter I has been written. This contains a layman's description of what a laser is and the various types of high energy lasers. This chapter will serve as an introduction to the report. Work has also begun on the writing of the classified annex describing the state of the art and the technology forecast.

4. Another brainstorming session was held at HDL on 8 July. Dr. Jones was present. Additional applications were suggested as well as some interesting viewpoints as to the basic nature of the laser's applicability.

5. During the next reporting period Dr. Jones is going to prepare a milestone chart for the performance of the impact analyses based on some of the applications that have come out of the two brainstorming sessions. The introductory chapters (including the classified annex) will be completed and the impact analyses will be begun.

6. At this point it appears necessary to have two outside studies performed. One is a series of rough calculations to determine the physical limits on the various parameters of high energy lasers; for example, the highest power, the greatest energy density, the longest range, the smallest volume, the greatest efficiency, etc. The second study is a conversion of power/energy/energy density delivered into "applications units", i.e. inches of stainless steel cut per minute, thickness of trees felled, depth of cut into granite, etc. If the money can be raised the studies will be performed as they would contribute directly to the technology forecast and the impact analyses.

E. A. BROWN
Project Manager - HELTA

18 Sept 1974

HIGH ENERGY LASER TECHNOLOGY ASSESSMENT [HELTA]
PROGRESS REPORT NO. 4
Covering the period: 9 July 1974 - 13 September 1974

1. The primary accomplishments of this period deal with the setting of the format of the final document and preparing the preliminary draft. The HELTA will be published in three volumes:

I. The Technology Assessment (Unclassified)
II. Lessons Learned in respect to the Army (Unclassified)
III. State of the Art and Technology Forecast (Secret)

2. Status of Volume I: Dr. Jones prepared an outline of the volume. The first four chapters dealing with background information on the report and on the technology have been written and sent out for critiqueing. The last five chapters dealing with the impact analysis and action options will be written during the next reporting period.

3 Status of Volume II: Dr. Jones has submitted an outline of the "Lessons Learned" volume, a copy of which has gone to Dr. Goldhar. Dr. Goldhar will collaborate with the Project Manager to write this volume during the next reporting period.

4. Status of Volume III: A first draft of the state-of-the-art volume has been written and sent out to the three services, ARPA, and the AEC for critiqueing.

5. Other accomplishments include a visit to NASA headquarters in Washington, D. C. (10 September) and a brainstorming session on the impact analysis and action options (12 September).

6. During the next reporting period a trip will be made to the NASA Lewis Research Center to gather input from NASA, and to the 1st DOD Conference on High Energy Lasers. The entire HELTA will be completed during the next period. For that reason this will be the last bi-monthly report.

EDWARD A. BROWN
Project Manager - HELTA

APPENDIX E

ADDITIONAL THOUGHTS ON TA

ADDITIONAL THOUGHTS ON TECHNOLOGY ASSESSMENT[1]

Doability.--Not all potentially useful enterprises are worth undertaking because they are beyond our present scope or competence. Consequently, the doability of the assessment becomes important. A very preliminary assessment may be necessary to determine this.

Budget.--A multi-disciplinary comprehensive assessment of a major technology with any degree of richness of input may involve the activities of six to thirty professional specialties over a period of a few weeks to one to two years. Consequently, the budget and staff must be considered against the availability of resources in competing functions.

Data Base.--In some cases the data required for analysis are either unavailable or not in the form that would be useful. Consequently, the generation of fresh data or the reorganization of available data may be a disproportionately burdensome task and hence obviate the possibility of effective assessment.

Redundancy.--The sponsor of an assessment should be aware of whether the subject under discussion has already been assessed. Is there something that can be built upon?

Political Sensitivity.--Not all important problems can be addressed at any particular time in a given institution or institutional environment because the political costs of even addressing the question, much less the political risks of possible outcomes, may be too great.

Transferability of Results.--This can be a useful criterion, particularly for an organization beginning a program of technology assessment. If a given assessment can bring strength to, shed light on, or illuminate the approach to other problems, this would tend to be a plus If it cannot do that, it is at least a neutral factor. For example, an attempt to assess the impacts of alternate work schedules may shed light on the question of assessing the impacts of alternative family structures, or alternative educational programs.

Is Anyone Listening?--To assess the impacts of a technology where there is no organizational structure or focus of responsibility, runs the very high risk of having no impact. If there is no institutional listener for the results, whose responsibility it is to act in the domain of concern, the most to expect is that the assessment will have diffuse long-term educational value.

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[1] Joseph Coates, "*The Identification and Selection of Candidates and Priorities for Technology Assessment*" Technology Assessment, 2, No. 2 (February 1974) p. 80 ff.

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Span of Responsibility.--Closely related to the last category is the fact that our world is organized and bureaucratized into institutions and organizations that have not only statutory but functional responsibilities which sharply limit their range of action. Organizational responsibility in or out of government does not fully map the range of the issue or responsibilities relating to many obviously crucial problems.

Institutional Support.--The institutional support structure either for or against technology makes it crucial to identify and draw upon an adequate range of parties at interest either to partake in the study or to be acknowledged and recognized as important components in the assessment of the impacts of the technology at hand.

Imminence or Timeliness.--Not all important technologies are at that degree of ripeness or timeliness that an assessment of impact can be appropriate. For example, it would be ludicrous in the extreme to study impacts of being able to modulate gravity waves. That technology is so far out on the margins of science fiction-science speculation that to assess its impacts would be somewhere on the wrong side of trivial to impossible. On the other hand, to assess the impacts of the technology too late in the decision cycle is likely to create strong polarization of attitudes and blunt the potential effectiveness of the study for the decision process. One cannot put too high an importance on assessing the state of the development of a technology so that the study may be timely in the decision cycle. Studies take time. One cannot do a 30-man-month study in one week or one month, in many cases, just because of the sequencing required by the logical progression from step to step.

Policy Relevance.--The formulation or statement of the technology to be assessed is crucial to success and strongly influences the policy relevance of the issues at hand. It should be borne in mind that the decision-maker asking for an assessment does so because he does not fully understand the technology's implications. It follows that he is likely to mistake the issue. The failure to apply the first law of operations research--question the question--can be disastrous.

Reduction of Uncertainty.--This should be a criterion particularly entering into the selection of either highly speculative technologies or those which are policy urgent. It may be that an assessment will be beside the point and not reduce uncertainty to a useful degree.

Structuring the Argument.--In many cases our understanding of a technology's impact is so shaky and uncertain that a principal function of a technology assessment, often one on a very small budget, is, so to speak, to structure the argument, give coherence to future discussion, or organize research or gathering of data. An example of this is the need to structure the argument around the impacts of biological technology in general, genetic engineering or alternative tax policies, etc.

Scope and Kind of Impacts.--While that seems to suggest that one has the answer before even framing the questions, experience shows that one can make fairly reliable preliminary estimates about the richness and breadth of impact of a given technology.

Scale of the Enterprise.--Obviously an enterprise involving billions of dollars and years of planning such as the TVA or major waterworks projects, etc, not only provides an opportunity for assessment but virtually demand an assessment in order to improve planning. On large scale projects, it is often difficult if not impossible to make corrections after the project is finished, whereas it might be relatively easy back at the planning stage.

Irrevocability.--Many projects cannot be called back or undone. It is unlikely that we would destroy a dam, rip up a highway network, or level a planned community. In the area of social technology revocability is often an available option. We do have the example of the Volstead Act, a major social technology undone after its negative consequences were made clear by experience rather than by anticipation.

Impacts on Future Contingencies.--Closely related to irrevocability is the extent to which a given project forecloses future policy options. The success of the automobile with the Otto cycle engine foreclosed developments of other modes of transportation based on other power plants which could have been usefully put forward. The building of one civil works project may foreclose other recreation or outdoor activities, militate against the exploration of an archeological site or flood a reserve, as the Aswan dam did to many monuments. The impact on future contingencies has rarely been considered in the past but is growing in importance for future decision making.

The Cost to Develop and Implement a Technology.--The higher the cost, the greater attention should be drawn to the wisdom of the decision, all other things being equal. Unfortunately, there are many common exceptions to this practice, e.g. military technologies.